Bulletin No. 37. *August, 1941.*

UNIVERSITY OF ALBERTA
COLLEGE OF AGRICULTURE

The Quality of Alberta-Grown Wheat

BY

A. G. McCALLA and DYSON ROSE
Department of Field Crops

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THE QUALITY OF ALBERTA-GROWN WHEAT[1]

A. G. McCALLA[2] AND DYSON ROSE[3]
Department of Field Crops

INTRODUCTION

Wheat has been, and is likely to remain for some time, the main cash crop grown by farms in Alberta. Whether Canada can regain sufficient markets to permit renewed expansion of wheat growing may be doubted, and it may even be found that production of wheat must be curtailed in order to maintain a reasonably balanced agriculture in western Canada. Regardless of these considerations, however, wheat will be an important crop in this province for many years to come, and a primary aim of all concerned must be to maintain and improve the quality of the crop so that it may command its full share of available markets.

It has been recognized for many years that the quality of the wheat grown in western Canada varies greatly from section to section, and also from year to year. The quality of wheat from any one locality may vary widely in different years, but usually the average quality of the whole crop of western Canada is reasonably constant. Abnormal years occur, as in 1927 when the quality was very low or in 1936 when it was considerably above average.

In 1938, this Department published a bulletin (Univ. Bul. No. 30) in which, among other things, the factors determining the quality of hard wheat were discussed. The final appraisal of quality must be arrived at by milling the wheat and baking bread from the flour. There are, however, several tests which can be carried out relatively easily and cheaply on large numbers of samples, and these permit a much more comprehensive survey of the quality of wheat grown than if all samples had to be milled and baked. The material presented in this bulletin illustrates the results of the more important of these tests, so no great elaboration need be given here.

The factor that is most closely related to wheat quality, and at the same time that may be easily estimated, is the protein content of the wheat. Within individual varieties the relation between protein content of different samples and their

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baking quality is usually close. Protein content has, therefore, been widely used in determining quality of wheat grown in Canada.

The Board of Grain Commissioners' Grain Research Laboratory at Winnipeg has carried out an extensive survey of the protein content of the wheat grown in western Canada for the past fourteen years. During that period the average for Alberta-grown wheat has been 13.3% while that for the whole western crop has been 13.6%. There is usually a great range in any one year, this range in 1935 being from 7.8% to 21.3% protein. Frequently the range for Alberta is nearly as great as for the whole west, so that variability in quality is one of the most characteristic properties of our crop.

While this annual survey by the Grain Research Laboratory is by far the most comprehensive of its kind, it takes no account of variety. It is well known that varieties differ in quality even at the same protein level. For example, Red Bobs or Marquis will produce a loaf of bread which is larger and of better texture and color than will Garnet of the same protein content. Thus the difference in distribution of varieties in various districts makes it difficult to appraise the baking quality of wheat from any particular locality when only protein results of unidentified samples are available.

As a result of work done in this department between 1932 and 1935, it became apparent that wheat produced in some districts was inferior to that grown in others even if the variety and protein content were the same. This was true despite the fact that we usually find protein content a good measure of quality within any one variety. Thus, the protein survey would class these districts as similar, but baking quality might actually be rather different.

These considerations led us to begin a quality survey of Alberta wheat. It was planned to start in 1935, but the widespread frost-damage that year made it inadvisable to begin on a large scale until the next year. Samples were collected from the Peace River area in 1935 and used in a preliminary study. From 1936 until 1940 annual surveys were carried out, and a discussion of the results of this five-year study forms the main part of this bulletin.

SOIL-CLIMATIC ZONES

Environmental conditions vary widely over the wheat-growing area of Alberta. This has led to the division of the province into four major zones, the division being based primarily on soil type. This division is definitely related to climatic factors since, over a long period of time, the climate is

perhaps the most important agent in determining the type of soil which develops in any area. The boundaries of the four zones are clearly marked on the map shown in Figure 1. Representatives of the Dominion and Provincial Departments of Agriculture and of the University of Alberta meet once a year to discuss experimental results and to make recommendations regarding the varieties of cereal crops most suitable for the various zones. This map has been gradually evolved by this group, modifications being made from time to time as additional information became available.

Fig. 1.—Soil-climatic zones.

In December, 1940, the boundaries of Zones 2 and 3 were altered somewhat in southern Alberta. The map here presented is not, therefore, the latest zonation map but, since all the results for previous years had been based on the older divisions, these are used throughout this bulletin. The alterations in the boundaries make no real differences to our results or conclusions, any change having the effect of raising slightly the general level of quality of wheat produced in Zone 3a.

No attempt is made here to describe in any detail the soil or climate of any of these zones. A few brief remarks are necessary, however. Zone 1, in the south-eastern part of the province, is relatively dry, the average annual rainfall over most of the zone being little more than 12 inches, while evaporation rate is relatively high. Moisture is unquestionably the factor which limits the production of crops in this zone. The light-brown soil is productive if sufficient rainfall occurs. Zone 2 is more variable, perhaps, but the average annual rainfall is higher by 3 inches or so, average evaporation somewhat less than in Zone 1, and the general productivity of its dark-brown soil is correspondingly higher. Zone 3 is the parkland section of the province, favored by higher annual rainfall and lower evaporation rate than are Zones 1 and 2 and possessing exceedingly fertile and productive black soil. Zone 3 is divided into two parts for the purposes of this bulletin because experience has shown that the factors affecting quality of cereal crops are, on the average, quite different for the two parts. The division is clearly marked on the map. The differences will be fully illustrated as the results are presented. Zone 4 is the most variable zone in both soil and climatic factors. In general the soil is of relatively low fertility, while in most parts moisture is usually not the deciding factor in crop production, since rainfall is reasonably good and evaporation rate lower than in most other parts of the province. This zone is also divided into two parts for purposes of this survey. Zone 4a, comprising all of Zone 4 except that part served by the Northern Alberta Railway west of Lesser Slave Lake, is a very large area, over which there is considerable variability in soil and climate, but all of which is characterized by relatively inferior conditions for the production of high quality wheat. Gray, wooded soil is the dominant agricultural type. Zone 4b, the Peace River area, is a distinct entity as far as situation is concerned and includes a considerable number of islands of black soil which is more fertile and productive than that of most of the zone.

The reader is referred to such publications as Alberta College of Agriculture Bulletins 11, 14, 16, 20, 21, 28, 31, and 32, and to Research Council of Alberta Reports 23 and 31 for details of soil and climatic conditions in various parts of Alberta. Detailed soil survey results are not available for all sections of Alberta, but for the purposes of this bulletin a general classification is sufficient.

DISTRIBUTION OF WHEAT VARIETIES IN ALBERTA

During the last five years there has occurred a decided change in the proportion and distribution of the varieties that make up most of the wheat grown in Alberta. From 1936 to 1938, Marquis, Red Bobs, Garnet and Reward made up about 97% of the total acreage sown to wheat, and even in 1940 these four made up 93.5% of the acreage, with Marquis and Red Bobs occupying 82.1%. When the separate grading of Garnet went into effect with the 1938 crop, the proportion of Garnet sown began to decrease, until in 1940 it had fallen to less than 7% as compared with 22.4% in 1936.

These changes in varietal distribution are reflected in our surveys, but since we had to restrict the number of samples collected, we did not expect to get a very accurate estimate of the varietal distribution for any one year. An extensive varietal survey is carried out each year by the Searle Grain Company, Limited. The figures obtained for 1936 and for 1938 to 1940 are summarized for Alberta in Table I. The results are self-explanatory, but attention is directed to the fact that the increased acreage of Red Bobs has occurred at the expense not only of Garnet, but to some extent of Marquis and Reward. It is very probable that Thatcher will increase in acreage, since our survey figures show that Thatcher is most popular in those areas where Garnet was formerly grown and where Red Bobs, because of its tendency to produce starchy kernels, is not a very satisfactory substitute. This is substantiated by the results of the Searle survey. Whether Thatcher will actually give the results expected may be questioned.

TABLE I.

Searle Grain Company estimates of the acreage of principal varieties expressed as percentages of the total wheat acreage in Alberta

Year	Garnet	Marquis	Red Bobs	Reward	Thatcher
1936	22.4	49.2	18.9	6.8	...
1938	16.5	44.8	29.5	6.3	0.3
1939	11.8	43.2	35.1	4.7	1.5
1940	6.9	40.1	42.0	4.5	3.7

In 1936 Marquis was the dominant variety in a large area in the south and east of the province, and in 1940 this was still the situation. In 1936 Garnet was the dominant variety in most of the remainder of the province, but in 1940 it was dominant only in some of the relatively unimportant wheat growing districts (as far as acreage is concerned) lying in Zone 4, the remainder of this zone having Red Bobs as the dominant variety. In 1936 Red Bobs was dominant only in small local districts, but in 1940 it was the main variety grown over a wide strip running from the northern boundary of wheat production to a point about half-way between Calgary and the

International boundary. East of Edmonton, Red Bobs was dominant to the Saskatchewan border.

These changes make a comparison of averages from year to year difficult. The purpose of this bulletin, however, is to discuss the quality of the wheat grown in the province. If a change in varietal distribution makes for an improvement in average quality this will be reflected in our average results. Furthermore, results for each zone are presented on the basis of individual varieties, so a fair comparison is easily made.

RESULTS OF QUALITY SURVEY

The results of any survey such as this, which involved the collection of from 200 to 300 samples a year, become very voluminous when the experimental work is carried on for five years. It is quite impossible to present in this bulletin anything but averages but, since it has been our aim to establish differences which are due to variety and zone, these two factors have formed the basis on which the averages have been determined. Where small or erratic variation has occurred from year to year, from zone to zone, or from variety to variety, the detailed numerical results have been omitted both to conserve space and to save the reader time in sorting out the more important from the less important differences. Thus, no detailed weight per bushel or flour yield data are given because there was little variability in these results as compared with those for protein content or loaf size.

Another way in which space has been saved is to combine the results for Zones 1 and 2. This is justified because the general level of quality over a ten-year period has been shown to be similar. Zone 1 wheat is, on the average, a little higher in protein content than that from Zone 2, but the difference is small compared with the differences between other pairs of zones. Combining the results has also permitted us to obtain varietal averages more truly representative of these zones than would be possible by taking each zone separately.

Finally, only results for varieties fairly common in the zone have been included here. Every year some samples of other varieties were received, but the results obtained with these cannot be considered representative and are, therefore, better omitted. One or two of these varieties such as Regent and Renown may become more important in the next few years, but most of them are gradually disappearing. During these five years we have received samples of Red Fife, Ruby, Early Red Fife, Huron, Ceres, Kitchener, and a number of mixtures. None of these varieties is important in Alberta and most of them are unsatisfactory for one reason or another. Some

samples were misnamed and a few were so badly mixed that it was impossible to tell what variety the farmer had intended to grow.

Number of Samples

The number of samples of each variety collected from each zone is given by years in Table II. The varietal changes discussed earlier are also noticeable here, particularly the great increase in Red Bobs and decrease of Garnet in Zones 3 and 4.

TABLE II.

Number of samples of each variety from each zone

Zone	Variety	Number of samples				
		1936	1937	1938	1939	1940
1 and 2	Canus	..	...	6	3	6
	Marquis	13	21	25	39	53
	Red Bobs	10	10	24	38	44
	Reward	4	1	2	6	6
	Thatcher	....	....	..	3	2
3a	Garnet	15	14	4	....	....
	Marquis	13	10	7	7	6
	Red Bobs	16	29	13	21	35
	Reward	3	2	4	2	4
	Thatcher	..	..	..	3	4
3b	Garnet	17	30	4	3	....
	Marquis	3	4	7	5	2
	Red Bobs	3	12	6	17	11
	Reward	6	5	....	....	....
	Thatcher	..	....	.	4	3
4a	Garnet	22	29	12	9	4
	Marquis	3	2	6	3	2
	Red Bobs	.	4	8	12	21
	Reward	6	3	12	9	8
	Thatcher	..	.	2	4	6
4b	Garnet	28	46	10	8	6
	Marquis	10	17	3	5	4
	Red Bobs	11	21	14	29	24
	Reward	12	22	15	9	7
	Thatcher	..	....	5	3	2

While the numbers of samples from some of the zones are small, the distribution is wide, and as will be seen under the discussion of the protein results, our averages are reasonably close to those of the much more extensive survey carried out by the Grain Research Laboratory.

Grade

Grade results are not presented. In 1936 and 1937 large samples of grain were collected and each graded separately. From 1938 on, small samples (one pound) were collected and only the composites based on zone, variety and protein content which were used in milling were graded. Grading of composite wheat samples is relatively unsatisfactory because one poor sample may affect the grade much more than it would if each sample were graded separately and the average calculated.

Nevertheless, the average grades were better in most years in the samples from Zones 1 and 2. Usually the grades of wheat from Zone 4a were the lowest, while those for wheat from Zone 4b were the most variable. It will be seen that this applies also to protein content and loaf volume. In general there is much less difference in the grades of wheat from the various zones than there is in other quality factors.

Weight per bushel and Flour Yield

Weight per bushel is a grading factor, but most of the wheat grown in Alberta is sufficiently heavy to satisfy the requirements of the top grades. Sometimes wheat samples from Zone 1 and, less frequently, a few samples from Zone 2, are degraded because they fail to reach the required weight per bushel. The wheat from the other zones is nearly always well above the minimum level unless damaged by frost.

It might be reasoned, therefore, that this is not an important quality factor for Alberta-grown wheat. Increased weight per bushel, however, is usually associated with increased flour yield and, hence, with greater milling returns. In this respect alone is the wheat grown in northern zones usually superior to that grown in Zones 1 and 2. It is usually found that both the weight per bushel and flour yield are lowest for Zone 1, but no one zone gives in general the highest results. The mean weight results for each zone over all five years were as follows: Zones 1 and 2, 63.2 lb. per bushel; Zone 3a, 64.1 lb.; Zone 3b, 64.4 lb.; Zone 4a, 64.7 lb.; and Zone 4b, 64.8 lb.

Protein Content

It has already been stated that protein content is very widely used in estimating the baking quality of wheat. In the five years of our survey, the protein content of each individual sample has been determined. These results, averaged by zone, variety and year are given in Table III.

No more than a casual glance at these results is needed to show that the protein content of wheat varies greatly from year to year and still more from zone to zone. Wheat of 12% protein or over is of sufficiently good quality to make satisfactory bread under many conditions, although bakeshops where rich formulas, high speed mixers, machine moulders, etc., are used require flour of at least 12.5% protein, which in turn must be milled from wheat of not less than 13% protein. Actually, the protein content of most of the wheat milled commercially in Canada is well above 12% and a large proportion is considerably over 13%. All of the wheat from Zones 1 and 2 and most of that from Zone 3a is well above this minimum level of 12 to 13%, when averages only are considered. This

does not mean that lower protein samples are not obtained, but that under normal marketing conditions no large shipments of wheat from these zones will be low in protein.

TABLE III.

Average protein content of wheat from each zone and variety.

Zone	Variety	Protein content, % 1936	1937	1938	1939	1940
1 and 2	Canus			14.2	13.0	14.8
	Marquis	15.9	15.0	13.9	14.2	13.4
	Red Bobs	14.9	14.6	13.4	13.5	13.4
	Reward	16.1	16.8	16.3	15.2	14.7
	Thatcher	....	....	....	14.3	13.0
3a	Garnet	12.2	14.3	11.9		
	Marquis	13.3	14.5	13.6	12.9	13.4
	Red Bobs	13.2	13.9	13.2	12.9	12.8
	Reward	15.0	15.8	15.3	14.2	15.6
	Thatcher	....	....	....	12.5	13.1
3b	Garnet	11.3	13.5	12.4	10.7	....
	Marquis	12.0	14.0	12.5	12.9	13.4
	Red Bobs	11.6	12.7	12.0	11.7	11.0
	Reward	12.4	13.1	....	....	....
	Thatcher	....	....	....	12.3	12.4
4a	Garnet	10.8	12.2	11.2	9.8	10.2
	Marquis	11.2	12.9	9.5	10.1	9.0
	Red Bobs		12.2	10.8	10.5	10.9
	Reward	11.6	12.6	12.0	11.8	12.4
	Thatcher	....	....	11.5	10.9	12.3
4b	Garnet	9.9	10.9	12.1	12.9	10.2
	Marquis	10.8	12.0	12.8	13.7	13.0
	Red Bobs	10.2	10.9	11.8	12.8	11.3
	Reward	11.9	13.2	14.3	15.7	14.4
	Thatcher	....	....	11.4	13.1	12.5

An entirely different situation exists for the other zones. Results for Zone 3b are sometimes above and sometimes below 12%, but as will be seen later, the general average for all samples and years is just over this value. This is, of course, an arbitrary value, and some persons concerned in appraising quality would set the figure higher by at least 1%. Few, we think, would set it lower. The mean results for Zone 3b, therefore, are definitely borderline. The direct importance of these results will be clearer after the discussion on blending.

Zone 4a produces the poorest quality wheat grown in the province. The average results show that it is unusual for it to come up to the 12% protein level. This means that there is a considerable volume of wheat concentrated in the northern and western parts of the province which, if not mixed with at least an equal volume of high-protein, prairie-grown wheat of the same grade, will be too poor in quality to satisfy even the domestic market. Buyers on the overseas market generally use Canadian wheat for blending with their own low-protein wheat and, for such a purpose, a protein level well above the minimum is obviously desirable in the wheat we send them.

The results from Zone 4b are the most variable. In 1936, this zone produced the poorest wheat, but in 1939 the general protein level was at least as high as that for Zone 3a. This variability is associated with the moisture conditions of the area. In 1935 and 1936, with rainfall considerably above average, the yields were high and protein low. In 1939, conditions resulted in much lower yields and much better quality. In 1940 the general level of quality was lower again. Despite the relatively good quality crops in such years as 1932, 1938, and 1939, the general average for Zone 4b barely reaches the 12% protein level.

Variety affects protein content, as can be seen from the results in Table III. Not all the variation within a zone and year is to be considered as directly due to variety, however, since in Zones 3b and 4b, for example, Marquis is almost exclusively grown on the better class soils of the zones. This is particularly true of Zone 4b, since Marquis can be successfully grown in some localities but would be entirely unsatisfactory in many others. In general, the conditions which permit the growing of this variety are found only in those parts of the zone particularly favored in fertility of soil. If Marquis were grown side by side with Red Bobs and Garnet, the differences in protein content would be much less than they appear to be from the results obtained in this survey. The only outstandingly high protein variety is Reward but, since this variety is low in yield and has some other undesirable quality characteristics, it is no longer recommended for this province.

In order that the validity of our protein results might be better assessed, we have summarized them together with the comparable results from the Grain Research Laboratory surveys and presented them in Table IV. There is only one really poor agreement—Zone 4a for 1938, when our average value was 1% lower than that of the more extensive survey. On

TABLE IV.

Average protein content of Alberta-grown wheat by zones, 1931-1940

Zone	1936		1937		1938		1939		1940		1936-1940 average		1931-1940 aver.
	U. of A.*	G.R.L.**	U. of A.	G.R.L.	U. of A.	G.R.L.	U. of A.	G.R.L.	U. of A.	G.R.L.	U. of A.	G.R.L.	G.R.L.
1 & 2	15.5	15.3	15.0	14.5	13.7	14.2	13.9	14.3	13.6	13.9	14.3	14.4	14.4
3a	13.1	13.6	14.3	14.2	13.4	13.3	13.0	13.2	13.2	13.3	13.4	13.5	13.2
3b	11.7	12.1	13.2	13.4	12.2	12.6	11.9	12.3	12.2	12.3	12.2	12.5	12.1
4a	11.0	11.2	12.2	12.2	11.2	12.2	10.8	11.2	10.9	11.0	11.2	11.6	11.0
4b	10.5	10.0	11.6	11.2	12.6	12.6	13.2	13.2	11.9	11.6	12.0	11.7	11.7

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**Grain Research Laboratory.

the other hand, our average results while slightly lower than the corresponding five-year figures are slightly higher than the ten-year average and probably represent very fairly the real position of Zone 4a. All the other results are as close as could be expected, and none of ours underestimates the average quality of the wheat from the northern zones. The comparison with the ten-year Grain Research Laboratory averages shows that conclusions based on our five-year survey can be generally accepted.

It has already been pointed out that wide variation exists within each zone. This is most easily shown graphically, and a summary of our own five years' results and the Grain Research Laboratory results for 1931 to 1938 are presented in Figure 2. Results for 1939 and 1940 are not included in the latter because only minimum, maximum and mean values for each shipping point were given in the published data for these two years. While the results shown in the two graphs are not for the same years, they may be considered as presenting a fair picture of the general results to be expected over any period of years.

Even in Zones 1 and 2, a small percentage of the samples was under 12% in protein. Nearly all of these came from shipping points where irrigation is a general practice. Irrigation may reduce the protein content of wheat grown in Zone 1 by as much as 4 or 5%, although such great reductions are the extreme rather than a general result.

Although the general differences between the results for Zones 1 and 2 and for Zone 3a are smaller in our survey than in the Grain Research Laboratory results, both graphs show that Zones 1 and 2 produce an appreciably larger proportion of wheat above any particular protein level than does Zone 3a.

The only other marked discrepancy in these two graphs is concerned with Zone 4b. As has already been pointed out, this zone has produced extremely variable results. Since the results for 1939, the highest protein year on record, were omitted from the Grain Research Laboratory figures while those for 1935, which was a low protein year, were omitted from our results, some divergence in the average curves must be expected. The correct curve doubtless lies somewhere between the two.

One of the interesting points about the graph line for Zone 4b in our own results is the way it is prolonged toward the high protein values. This simply means that we have secured a small percentage of samples higher in protein than were obtained in the larger survey. This is possibly accounted for by the fact that many of the better farmers in the area

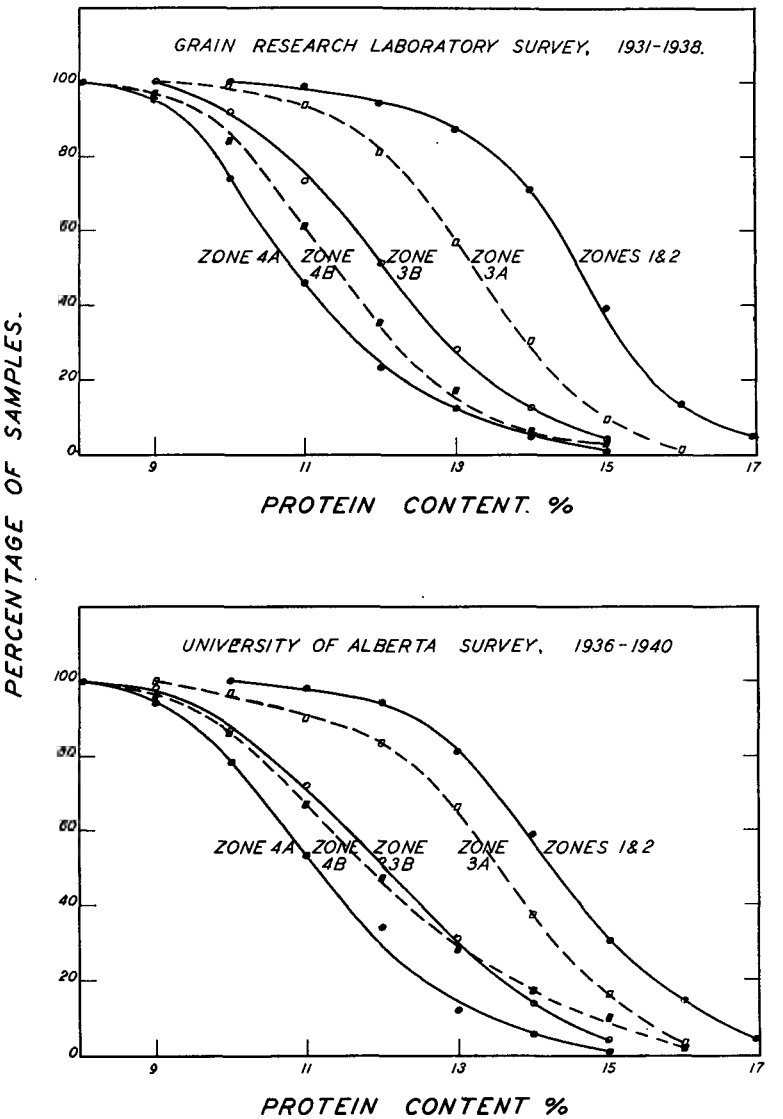

Fig. 2.—The percentage of samples from each zone above any specified protein content.

between Clairmont and Beaverlodge have shown a keen desire to assist in this survey and have been regular contributors of samples. Since this part of Zone 4b usually produces the best quality wheat in the zone, our results may be slightly favorably biased for the zone as a whole.

The distribution of protein results within Zone 4b is of definite interest. The Grain Research Laboratory results for 1931 to 1938 have been studied in detail.* The zone was divided into five districts as follows: (1) Peace River to Reno; (2) Roma to Hines Creek (including Battle River); (3) Watino to Spirit River; (4) Enilda to Girouxville; (5) Sexsmith to Hythe.

The average protein results for eight years showed that the last district produced the highest protein-content wheat with 11.9%, districts 2 and 3 the next with 11.5%, district 1 next with 10.5%, and finally district 4 with only 10.4% protein. The lowest yearly average recorded during the eight years was 9.4% in district 4, 1935, and district 3, 1936. The highest value was 13.4% protein in district 5, 1932. Undoubtedly 1939 results would have been higher for some of the districts.

Thus it must be concluded that there is wide variability in the protein content of Alberta-grown wheat. Not only does it vary from zone to zone, but there is marked variability within individual zones from year to year. Despite these factors, however, Zones 1, 2, and 3a are unlikely to produce large shipments of low protein wheat, but Zones 3b, 4a, and 4b may do so. Wheat from most of these three zones goes to Vancouver for overseas shipment, and there is definite danger of large shipments remaining segregated after reaching the terminals. The importance of this will be more obvious after the discussion of the two following sections.

Size of Loaf

The final and most convincing test of quality is, of course, the baking of the flour into bread. Every sample collected in the 1936 and 1937 surveys was milled and baked individually. From 1938 to 1940, however, the samples were composited by zone, variety, and protein content. These composites were then milled and baked. Thus, in 1940, when we collected some 270 samples, we milled and baked only 63 composites. This system, however, gives us a very good picture of the quality characteristics of each variety in each zone, even if the extremes are not included individually.

*Grateful acknowledgement is made to Mr. A. D. Paul, a former member of the staff of this Department, who carried out this study.

The average size of loaf of each variety from each zone and year is given in Table V. The same formula* and same amount of flour were used in baking all loaves. The differences in bread were, therefore, directly attributable to the properties of the flour. Within each variety the loaf size is directly related to protein content, a fact best shown for the main varieties by the results in Figure 3. There are too many individual values to include in this graph, but the lines represent the relation between loaf volume and protein for each of these varieties. By using a suitable mathematical procedure it is also possible to calculate the percentage of the variability in loaf volume which is directly attributable to the variability in protein content. Such calculations show that 86% of the variability in loaf size of Marquis is caused by differences in protein content, 84% with Red Bobs, 82% with Garnet and 74% with Reward. Comparable and even higher figures have been obtained in other studies. Therefore, as far as the features of quality which are measured by loaf size are concerned, protein content does give an accurate estimate within varieties.

TABLE V.

Average size of loaves from each zone and variety.

Zone	Variety	Loaf size, cubic centimetres				
		1936	1937	1938	1939	1940
1	Canus			808	895	790
and	Marquis	789	886	777	777	747
2	Red Bobs	830	830	764	788	728
	Reward	890	958	928	995	755
	Thatcher				965	
3a	Garnet	588	686	600		
	Marquis	744	826	809	742	663
	Red Bobs	723	778	796	769	657
	Reward	868	870	883		680
	Thatcher				740	835
3b	Garnet	533	610	543	485	
	Marquis	662	780	717	780	695
	Red Bobs	666	720	708	677	629
	Reward	507	665			
	Thatcher				580	545
4a	Garnet	496	543	464	448	435
	Marquis	586	742	496	520	450
	Red Bobs		681	624	507	619
	Reward	577	617	604	682	589
	Thatcher			535	595	630
4b	Garnet	502	513	530	643	428
	Marquis	614	675	712	780	700
	Red Bobs	618	647	665	756	656
	Reward	646	728	805	812	742
	Thatcher			589	695	600

*This formula is as follows: 100 gm. flour, 3 gm. Fleischmann yeast, 2.5 gm. sugar, 1 gm. salt, 0.3 gm. malt extract (250 deg. L.), 0.1 gm. ammonium phosphate, 1 mgm. potassium bromate, and water.

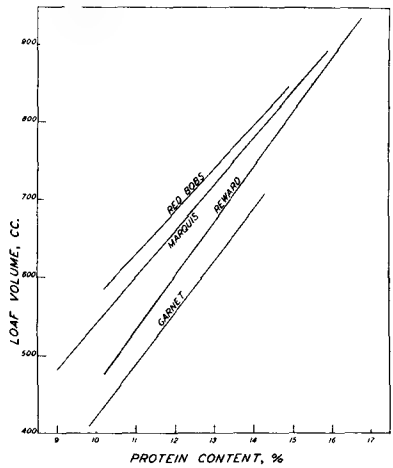

Fig. 3.—Relation between protein content and loaf size.

The fact that only within varieties can this relation be accepted as an adequate measure of quality is also shown by the results in Figure 3. In order to make a loaf of any specified size Garnet wheat must be about 2 to 2.5% higher in protein than Red Bobs. Thus, by knowing the protein content of wheat but not knowing the variety, a person may make an inaccurate estimate of the true quality of the wheat. Whether this is now a major consideration commercially may be doubted, since most cargoes will be mixtures of varieties. In many small mills, however, it is an important factor in determining the quality of the flour. In 1936, when this survey was begun, it was a much more important factor than it is today because the percentage of Garnet grown in the northern zones has decreased very rapidly since 1938.

Not only Garnet, but also Reward, makes poor bread when the wheat is low in protein. For several years Reward was recommended as the best quality, early variety for the north. Since then, extensive investigations have shown that while high protein Reward makes good bread, low protein Reward does not. However, Reward is nearly always 2% or so higher than Garnet in protein content when grown under comparable conditions. Thus, the Reward would always be of much better quality than the Garnet. (See Table VIII.)

An illustration of the effects of protein content and variety on the type of bread produced is given in Figure 4. Necessary details are given on the photograph. Not only is the size of the loaf affected, but also the texture and color are better in

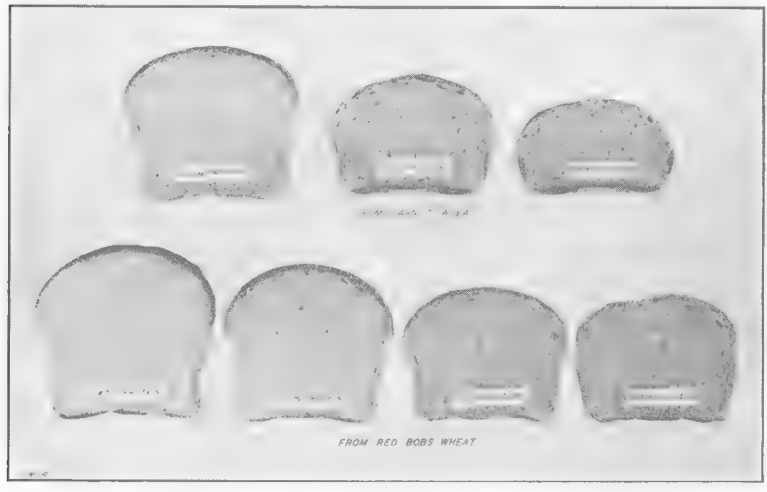

Fig. 4.—Loaves of bread baked from Red Bobs and Garnet wheat samples of various protein levels.

the bigger loaves. The smaller ones tend to be soggy, and because they weigh approximately the same as the larger ones, are heavy and unpalatable.

Why is loaf size an important characteristic, and does it really measure quality? In order to answer this question, we must consider what the flour is to be used for. Most of our hard wheat is used for baking bread, and under normal conditions it is used in blends with much weaker European wheats. Western Canadian wheat is considered as "strong" wheat, which means that it will improve the strength and quality of low-protein, soft-wheat flours when used in a blend. This in turn means that a larger loaf of better texture can be made from the blend than from the weak wheat flour alone. Many of the samples collected in this survey were higher in protein content than is desirable when used alone in bread-making. Such wheats are "too strong", that is, there is too much protein in the flour in proportion to starch to make a well proportioned, well balanced loaf. The loaf may be undesirably large. On the other hand, such flour added in a blend will raise the protein content of the blend more than will a medium or low protein sample of our wheat. The loaf size, then does measure the potential capacity to improve weak flours, which is the main reason Canadian wheat is bought by European importers.

The importance of this consideration is shown by the results in Table VI, which give the increases or decreases in the size

of the loaf from a weak flour when it was blended with 50% of each composite. For 1936 to 1938 the weak flour was itself from a blend of English (40%), Argentine (30%), and Australian (30%) wheats. This is a common type of mixture to which Canadian wheats are added to give extra strength. In 1939 the test was not made, and in 1940 a blend approaching that used in earlier years was prepared in our own laboratory.

TABLE VI.

Effect of the zone averages on the loaf size of a weak flour blend. (Zone average and weak flour used 50-50)

Zone	Variety	Loaf volume, increase cc. 1936	1937	1938	1940
1 and 2	Canus	..	...	110	125
	Marquis	89	124	89	73
	Red Bobs	112	92	77	79
	Reward	109	166	105	65
3a	Garnet	— 6*	55	—50*	.
	Marquis	59	106	74	50
	Red Bobs	52	56	69	72
	Reward	99	109	92	3
	Thatcher	....	....	....	133
3b	Garnet	—60*	—23*	—25*	.
	Marquis	2	82	25	30
	Red Bobs	5	35	30	35
	Reward	—13*	42	....	.
	Thatcher	....	....	....	—52*
4a	Garnet	—121*	—39*	—75*	—78*
	Marquis	—29*	64	—45*	—68*
	Red Bobs		12	7	42
	Reward	—26*	26	— 4*	6
	Thatcher	..	.. .	—55*	—38*
4b	Garnet	—79*	—56*	—41*	—72*
	Marquis	—19*	39	47	87
	Red Bobs	—19*	— 1*	21	61
	Reward	7	57	70	78
	Thatcher	.. .	....	15	5

*A minus sign means that the zone average weakens the blending flour instead of improving it.

The protein content of the weak flour was about 10%, equivalent to a wheat protein of about 10.5%. The loaf volume of the blend was in general increased or decreased according as the wheat protein of the added zone average (see Table III) was above or below a minimum level for each variety. The effect of protein quantity is modified by protein quality. Thus, we saw in Figure 3 that, starting with Garnet, it required progressively less protein of Reward, Marquis, and Red Bobs to produce a given loaf volume. There are too few data to enable us to make any general statements regarding Thatcher and Canus, but results obtained in other experiments indicate that these varieties both give good relative loaf volume at any particular protein level.

While the degree of improvement which must be obtained in order that the zone averages may be considered satisfactory

for blending is difficult to determine, it can be safely assumed that unless there were at least a 50 cc. increase in volume of the loaf, an importer would consider the wheat very unsatisfactory. Actually this is probably too low a figure.

It has been the experience of some visitors to European mills to find that a cargo of Canadian wheat, which was bought by the mill for the one purpose of strengthening the blended flour, was no better than the material it was supposed to improve. This leads to intense dissatisfaction on the part of the miller, who is quite likely to try to strengthen his mix by wheat from another source.

The results in Table VI show that, on the average, our northern-grown wheat is not sufficiently strong to meet the requirements of overseas buyers. On the other hand, if we could be sure that this wheat was thoroughly mixed with the prairie-grown material, there would be no cause for worry about the average level of quality, since the averages for all but Garnet wheat from Zones 1, 2, and 3a are well above the level necessary to effect marked improvement. The type of effect which can be expected is shown in Figure 5 in which

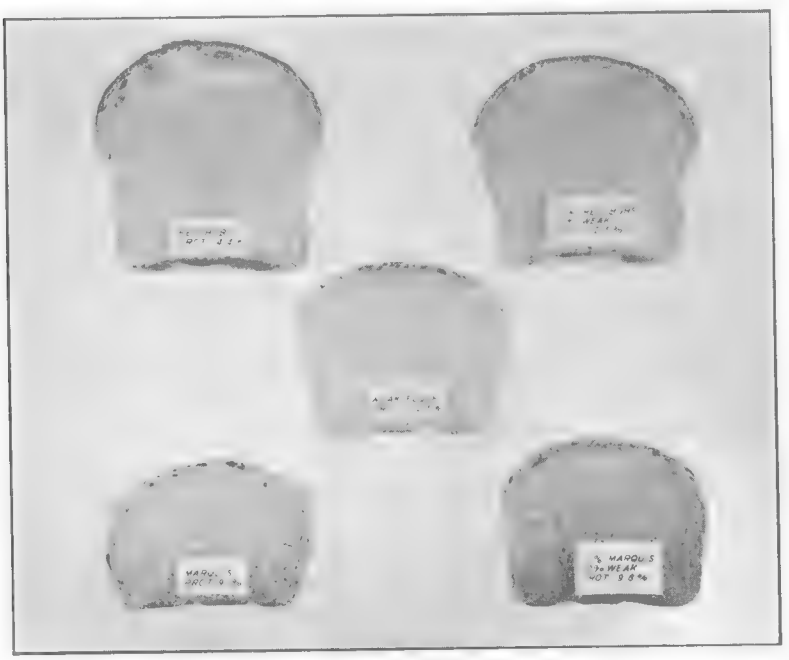

Fig. 5.—The effect of blending a weak flour with 50% of a high protein or a low protein flour.

photographs of the bread baked from blends are compared with ones of bread baked from the weak composite and the original Alberta wheat. The high protein flour improves the weak flour, but the low protein Marquis is itself improved.

One further point may be mentioned in this section. Frequently we are asked whether the formula and method of baking we use ensure that the best possible bread will be made from any particular flour. The answer, of course, is "No". Nevertheless, this answer must be conditioned by adding that our methods do give the best available measure of those quality characteristics necessary to ensure that the importer will get what he needs. These methods may not be adequate to determine the true value of a new variety but, when we are convinced that a variety has satisfactory properties, we can use this baking method with confidence.

Texture and Color of the Bread

Detailed texture and color results are not tabulated here, but a few general comments may be made. These two factors are to some extent associated with loaf size. If a loaf is small it is likely to have a heavy, soggy texture which in turn will make the color dark and unpleasant. If, on the other hand, the loaf is very large, the texture is likely to be open, because the total weight of material present is just the same as in the small loaf. This open texture results in a light, fluffy loaf, which indicates great strength in the flour, but would by itself be rather unsatisfactory for commercial use.

Bread made from wheat grown in Zones 1, 2, and 3a is almost always of good texture and color. Results for northern zones are frequently poorer, but they vary from season to season, and variety to variety. Zone 4a has consistently produced bread of poorer texture and color than has any other zone. The bread produced from Garnet is usually of poorer texture and color than that from the other commonly grown varieties. The average results for the five years are given with the other summary data in Table VII.

Summary of Quality Results

A summary of the more important results of the five-year survey is given in Table VII. This gives merely the averages without any emphasis on the more important varieties for each zone. In 1936 Garnet was the most important in all northern zones but in most areas of these zones Red Bobs has largely replaced Garnet. There can be no question but that this change has made a marked improvement in the general quality of the wheat, even though the protein level is much the same. The effect is very well illustrated in Figures 6 and

7 in which photographs of bread made from the dominant variety in each zone for 1936 and 1940 are shown. Except for Zone 4b, the protein content of the Red Bobs in 1940 is fairly close to that of Garnet in 1936. The differences, therefore, are directly attributable to the change in variety.

TABLE VII.

Summary of five years' survey results.

Zone	Variety	Total number of samples	Protein content %	Loaf size cc.	Effect on a weak blend* cc.	Texture**	Color**
1 and 2	Marquis	151	14.5	795	93	7.6	7.5
	Red Bobs	126	14.0	788	90	7.4	7.3
	Reward	19	15.8	905	116	7.8	7.6
3a	Marquis	43	13.5	757	72	7.5	7.4
	Red Bobs	114	13.2	745	62	7.4	7.2
	Reward†	15	15.2	825	76	7.2	7.3
3b	Garnet†	54	12.0	543	—41	5.6	5.5
	Marquis	21	13.0	727	35	7.3	7.2
	Red Bobs	49	11.8	680	26	7.1	7.1
4a	Garnet	76	10.8	477	—78	5.1	5.1
	Marquis	16	10.5	559	—35	6.1	6.3
	Red Bobs†	45	11.1	608	22	6.4	6.2
	Reward	38	12.1	614	0	6.5	6.4
4b	Garnet	98	11.2	523	—62	5.0	5.1
	Marquis	39	12.5	696	38	7.2	7.2
	Red Bobs	99	11.4	668	15	7.1	7.0
	Reward	65	13.9	747	53	7.2	7.2

*Four years' results. A minus sign means that the effect was deleterious instead of beneficial.
**Perfect score equals 10.
†Four-year averages only.

The most important conclusions to be drawn from this summary are as follows:

Except for slightly lower weight per bushel and flour yield, wheat from Zones 1 and 2 is the best in quality. The higher protein content and general baking quality so far offset the slightly lower flour yield, however, that there can be no question but that wheat from Zones 1 and 2 is the best. Except in a very abnormal year, not encountered during this survey, it is certain that wheat from Zones 1 and 2 will meet every demand for strong, high quality hard wheat.

The wheat from Zone 3a is somewhat lower in quality but is, on the average, still sufficiently high in protein and general baking properties to satisfy the ordinary demands made on hard wheat.

The wheat from the remaining zones, however, may in some years be far below the level of quality demanded in hard wheat either for domestic or export use. Zone 3b is borderline, Zone 4a definitely poor, and Zone 4b the most variable from year to year in the province. The average quality of wheat from all these zones is only fair and many individual districts are much below the average.

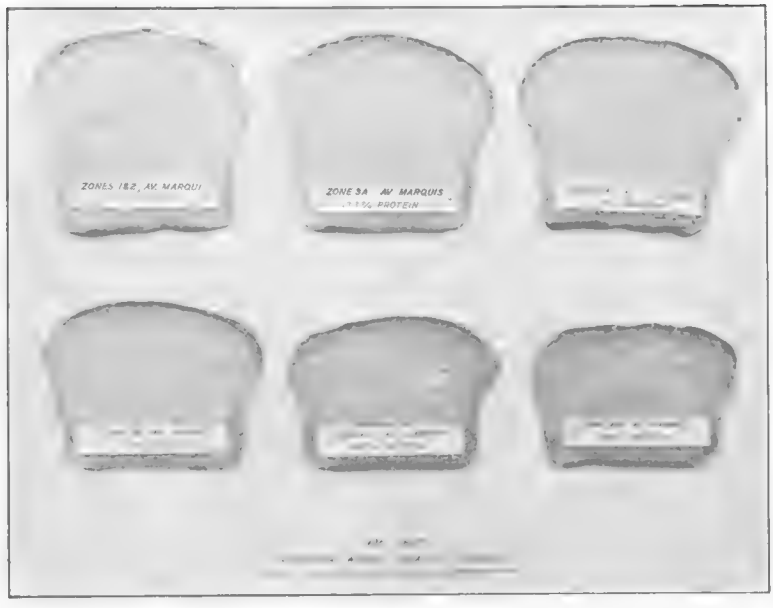

Fig. 6.—Bread baked from the zone average of the variety most commonly grown in each zone, 1936.

Fig. 7.—Bread baked from the zone average of the variety most commonly grown in each zone, 1940.

The variety of wheat grown has a decided effect on quality, and the change from Garnet to Red Bobs in the northern zones has made an improvement, even though protein content has been little affected.

IMPORTANCE OF QUALITY RESULTS

Many persons have questioned the importance of these results from the practical point of view. They argue that the wheat from all parts of western Canada is mixed, and these results show that the average level of quality is satisfactory. Unfortunately, the northern-grown Alberta wheat is less likely to be mixed with prairie-grown high-quality wheat than is that from any other part of western Canada. In normal times, most of this wheat goes via C.N.R. to Vancouver and is exported from there. The main line C.N.R. carries little wheat except that produced in the northern zones and parts of zone 3a. Thus, in a normal year, relatively huge quantities of this wheat may be segregated from the better quality material from the prairies, and be exported without any mixing. Not all such cargoes will be unsatisfactory, but some of them are bound to be.

Anyone who has any doubt as to the validity of these statements need only refer to the annual reports of the Grain Research Laboratory at Winnipeg. The report for the 1938-1939 crop year shows that the average protein content of each grade except No. 1 Hard was appreciably lower (0.5 to 1.3%) for Pacific than for Atlantic shipments. While the minimum protein content of any Atlantic cargo of No. 1 Northern wheat was 13.1%, one such Pacific cargo was only 11.9%, and nine other cargoes were under 13% protein. Three cargoes of Pacific No. 2 Northern were under 12% protein and forty-three others were under 13%, but no Atlantic No. 2 Northerns were under 12%, and only one cargo was under 13%. In the report for the 1939-1940 crop year, equally large differences are shown. No Atlantic cargoes of either 1 or 2 Northern were below 13% in protein, but twenty cargoes of Pacific 1 Northern and nineteen cargoes of 2 Northern were below this figure. These thirty-nine cargoes represented only a small part of the export wheat of Canada, but they made up nearly two million bushels which was 37% of the total of these grades exported from Vancouver. It is certain that the importer receiving a cargo of 1 Northern wheat which contains under 12% protein will be very much disappointed with its quality.

It must be emphasized that such variability is not the fault of the grain inspectors. The only factor in grading which is related to the baking quality, as distinct from flour yield,

is the percentage of vitreous kernels which a sample must contain in order to be placed in any particular grade. Starchy kernels give a rough indication of low protein content. Thus Red Bobs, which produces starchy kernels more readily than any other common variety, is probably the most fairly graded from the quality point of view. This is recognized, if not understood, by farmers in Zone 4a who find that Thatcher, which does not show starchy kernels as readily, will give a little better grade. It must be stressed that, although on the average, the grading system works well, the grade of an individual sample may have little true relation to quality. While it is unusual to get No. 1 Hard wheat of very low protein, it is a common occurrence to get from northern zones No. 2 Northern and even some No. 1 Northern samples containing not over 10% protein. When it is realized that a high protein sample of No. 5 or No. 6 wheat will probably make as large a loaf as a low protein No. 1 or No. 2, it will be admitted that, regardless of how efficient the inspectors are, the grade of particular samples is no guarantee of quality. In general, of course, it gives a reasonable assurance of the quality to be expected.

That is the dark side of the problem. There is a brighter side. Although the amount of this poor wheat is not negligible (the average yearly production in Alberta for Zones 3b and 4 from 1936 to 1940 was thirty-one million bushels) it is not a large proportion of the total Canadian crop. If we could ensure mixing of all wheat within a grade there would, as many say, be no problem at all. Since this is impossible, it is essential that every means of raising the general level of quality of northern-grown wheat be explored. The ways of doing this are discussed in the next section.

IMPROVING THE QUALITY OF NORTHERN-GROWN WHEAT

There are two ways in which the quality of wheat may be altered, as has been shown in the preceding discussion. The first is concerned with the variety of wheat, and many persons and research institutions are busy with the problem of trying to produce a new variety which will improve the general average of quality of northern-grown wheat. So far, results indicate that no great success will be attained by this approach alone.

This can best be illustrated by considering very briefly a few results which have been obtained. Reward wheat is always higher in protein when grown under the same conditions than are our other standard varieties. Thus we can raise and have raised the general level of quality as measured

by protein content. It is very probable that we could breed a wheat which would have the high protein content of Reward and the protein **quality** of Marquis or Red Bobs. Such a wheat would be more satisfactory in quality than anything now grown in the northern parts of western Canada.

It has been found, however, that such high protein varieties are almost invariably low in yield, and there is no use asking a farmer to grow such a variety if he gets 25 to 30% less yield than does his neighbor who grows Red Bobs. So far our results and those of other investigators have failed to indicate any great hope of obtaining a high-yielding, high-protein hard spring wheat. Thatcher appeared to offer promise, since on the prairies it is definitely both high-yielding and high protein. From extensive experiments carried out in many parts of Zone 4, it appears that either the yield or protein content is adversely affected under these conditions, that is, if Thatcher maintains its yield equal to that of Red Bobs, the protein content will be very little higher; if, on the other hand, the protein is much higher, yield is reduced. A summary of results of fifteen tests carried out in Zone 4 during 1938, 1939, and 1940, is given in Table VIII. These show that the yields of Marquis, Red Bobs, and Thatcher are essentially the same, and much superior to that of Reward. The protein content of Thatcher is a little higher than that of Red Bobs, but the loaf volume is very little superior.

TABLE VIII.

Comparison of yield and quality of wheat varieties in Zone 4.

Variety	Yield in bus. per acre	Protein, %	Loaf size, cc.
Garnet	25.3	12.3	529
Marquis	26.4	12.2	642
Red Bobs	25.7	12.0	663
Reward	20.3	14.1	751
Thatcher	25.3	12.5	681

In 1940, samples of Reward wheat from widely separated areas in Zone 4a were tested and found to contain in a few instances only 10% protein. Similarly, one set of Red Bobs samples contained only about 8% protein. **Nothing that we can do in a breeding program** will make the wheat, grown under conditions such as these, of satistactory quality.

The survey results show much greater variability in quality as a result of the location in which the wheat grew than as a result of variety effects. Owing to these differences in environment, caused by differences in soil and in rainfall, a single variety will vary extensively in quality. We must, therefore, turn to ways and means of altering the environmental factors.

Very little can be done about climate. It is fortunate from a yield standpoint that there is usually a fair supply of moisture in most parts of Zones 3 and 4. If moisture were as limiting in Zone 4 as it is in Zone 1, the quality of wheat would be much better than it now is, but yields would shrink to the vanishing point.

The farmer, however, has a very real control over the fertility of his soil, and it is in this control that the greatest hope of raising the average quality of northern-grown wheat lies. Most of the soil in Zone 4 is very low in nitrogen, the most important factor in determining protein content, low in sulphur, and low in organic matter. To ensure any appreciable improvement in the productivity of these zones and in the quality of wheat produced, these deficiencies must be remedied.

For the past eleven years, extensive experiments have been carried out at Breton by the Department of Soils of this university. The soil is a typical gray soil characteristic of much of Zone 4. The field had been cropped before experiments were begun and was giving very poor yields. The reader is referred to "Wooded Soils and Their Management", University Bulletin 21, for details of these experiments. Only a short review of the most pertinent data can be given here.

These experiments show that both yield and quality of wheat can be decidedly improved when the most suitable management methods are used. The soil is greatly improved when legumes are grown, and the succeeding wheat crop is better in quality than where no legumes are grown. In order to ensure the best results with legumes, fertilizer must be used on the legume crop and likewise it must be used with the succeeding grain crop in order to get the greatest benefit from the residue of the legumes. The recommended fertilizers are ammonium sulphate or 16-20 ammonium phosphate applied at the rate of 50 to 60 pounds per acre for the grain crops, and perhaps somewhat lighter for the legumes.

Some idea of the effects of the system of management involving legumes and fertilizers may be gained from the following figures: Where no legumes were grown and no fertilizers used, the average protein content of wheat grown continuously was 10.5%; but where legumes were grown and one of the recommended fertilizers used on both legumes and wheat, the comparable average protein content of the wheat was 13.6% for ammonium sulphate plots, and 13.2% for ammonium phosphate plots. A direct comparison of wheat after summerfallow cannot be made since summerfallow plots were sown to wheat in only two of the ten seasons during which wheat was grown after clover. For these two years, however, the

no-fertilizer, no-clover plots produced wheat of 9.9% protein while the protein content of wheat from fertilized clover plots was 14.8% (ammonium sulphate) and 14.2% (16-20 ammonium phosphate).

In the foregoing experiments, however, each plot received the same fertilizer treatment year after year. This results in a gradual accumulation of effects, and it is unlikely that as striking results would be obtained under normal farm conditions.

In 1936, our own department began a series of experiments at Fallis, designed to test the effect of legumes and fertilizer under farm conditions on wheat quality. In some areas where soft wheat is grown, considerable success in raising protein content has been obtained by using nitrogen fertilizers after the wheat has made a good start in its growth. It seemed likely that nitrogen fertilizer applied as late as possible without causing injury to the crop, would raise the protein content of the wheat materially. In practice it was found that this application was best made at the time the wheat was in the early boot stage, which at Fallis was usually about June 20. Our experiment was designed with a check (no fertilizer) and four different treatments involving a high nitrogen fertilizer, either ammonium sulphate or 16-20 ammonium phosphate. Each year the plots were laid out on land which had grown at least one crop since being fallowed. In 1938, the experiment was repeated on a piece of land which had been in grass and clover for some years. In 1939, it was repeated on another section of this clover and grass land which had grown a very poor but uniform crop of wheat in 1938. In each experiment the individual treatments were replicated five times and Garnet and Reward wheat grown on each replicate. The final result for each test, therefore, is an average of ten individual results and it is possible to calculate exactly how large the differences in yield, protein content, and loaf volume results must be in order that we may say that the effect of legume or fertilizer is significant.

The 1936 and 1937 seasons were very dry, and comparatively little value was obtained from the fertilizer. The 1938 and 1939 seasons were much better in this respect and excellent results were obtained. A summary of yield and quality results for 1938 and 1939 is given in Table IX. The effects were much the same for the two years and for both varieties, so the results have been averaged.

There is no question but that a combination of a preceding legume and fertilizer gives the best results as far as yield is concerned. The effect of normal applications of fertilizer on protein content is not very great; in fact, there is a tendency

for protein content to be reduced as compared with the check on legume soil. This doubtless results from the stimulus given by the fertilizers to yield, the available nitrogen being thus distributed over more bushels of wheat. There is, however, no corresponding reduction in loaf volume.

TABLE IX.
Results of fertilizer tests at Fallis, 1938 and 1939.

Fertilizer treatment	Yield, bu./acre		Protein, %		Loaf size, cc.	
	After wheat	After grass and clover	After wheat	After grass and clover	After wheat	After grass and clover
1. None	10.8	15.8	10.7	13.6	540	661
2. 60 lb. at seeding*	15.2	23.4	10.7	12.4	560	677
3. 120 lb. at seeding**	15.6	24.4	11.1	13.0	566	694
4. 60 lb. at seeding*, 60 lb. later**	16.0	24.7	11.4	13.2	565	718
5. 120 lb. later**	13.2	19.3	12.2	14.2	612	804

*Fertilizer placed in the drill rows.
**Fertilizer applied on the surface.

Late applications of fertilizer certainly improved the quality of the wheat following clover but, except in the deferred heavy application, had little effect on the continuous wheat. It must be emphasized, however, that this part of the experiment was a failure from the practical point of view. Heavier treatments than 60 pounds of fertilizer per acre did not give enough added yield to pay the cost; deferring part of the treatment made no significant difference, and deferring the whole application resulted in a smaller increase over the check. The treatment did not improve the grades.

The demonstration that, under normal farm conditions with the most efficient management of these soils (legume+60 pounds fertilizer), the protein content of the wheat grown could be raised nearly 2% as compared with wheat grown on land which has not previously grown legumes, was certainly a success. It seems possible that the results obtained at Fallis and Breton may not be applicable to Zone 4b since the Beaverlodge Experimental Station studies fail to give such positive results. Nevertheless, **if all wheat from Zone 4a were grown only on land which had previously grown legumes,** we could expect the general level of quality to be raised very materially. The importance of this can be judged by the following considerations:

The raising of the average protein content from 11.0% (see Table IV) to 12.5% (a conservative estimate of the effect of legumes) would leave a very small problem. The minimum protein content of any large cargo of wheat could then be expected to be at least 12% instead of 10.5 or 11.0% as occasionally happens now. At the present time it requires two million bushels of 14.0% protein wheat to raise the

average protein content of a blend with one million bushels of Zone 4a wheat to 13.0%. Under the hypothetical conditions, it would require only half a million bushels. These, of course, are average figures, and in some years the quality of northern-grown wheat would be well below the desired level of quality. On the average, however, there need be no hesitation in concluding that a great improvement in the quality of this wheat could be accomplished. **At the same time the farmer would increase his yields and his cash returns.** This would require mixed farming, because the legumes must be fed as pasture and hay. A discussion of this phase of the problem is outside the scope of this bulletin.

The results of these fertilizer tests illustrate very well the point raised in the introduction concerning the poorer quality of wheat from certain districts even where variety and protein content were the same. Where legumes preceded wheat and fertilizer was used, the quality as determined by loaf size and properties was equal to or better than that of the no-fertilizer check even though the protein content was significantly lower. In fact, had there been no effect of legume and fertilizer on protein quality, the loaf of bread made from wheat given sixty pounds of fertilizer at seeding should have been at least 70 cc. smaller than that made from wheat grown without fertilizer. Instead, it was 16 cc. larger, although this is an amount too small to be considered significant.

This result is not peculiar to our experiment. For five years the samples grown at Breton by the Department of Soils have been baked in our laboratory. Invariably the wheat grown after clover and fertilized with ammonium sulphate or 16-20 ammonium phosphate has yielded better bread than would have been expected from the protein content as compared with that of the control. The difference on an average of five years is not less than 100 cc. better than the check, after allowing for protein differences. The importance of such a result can be fully appreciated if the loaf size results in Table V are reviewed. Thus it is clear that soil fertility affects both quantity and quality of wheat protein.

RECOMMENDED VARIETIES OF WHEAT

It has already been stated that there is held annually a meeting at which results and recommendations are discussed and from which comes the list of recommended varieties of cereal crops for Alberta. A copy of these recommendations may be obtained from the Field Crops Branch, Department of Agriculture, Province of Alberta (not the University).

It is appropriate, however, that there be some mention of the wheat varieties considered satisfactory for the province

included in this bulletin. There are only four on the list at present.

Marquis, because of its quality, is taken as the standard in deciding whether a new variety should be admitted to the contract grades. It is not only the official standard of quality in Canada, but is the nearest approach to an international standard of any variety grown. Marquis is suitable for any district in which frost and stem rust are not limiting factors in production. Rust is relatively unimportant in Alberta in a normal year. Officially this variety is recommended for Zones 1 and 2, and for parts of Zones 3 and 4b where specially favorable conditions are to be found.

Canus is a bearded wheat with good length of straw. It is slightly later maturing than Marquis. It has been, over a period of years, the highest yielding variety in the tests carried out by this department under drought conditions. This variety is slightly lower than Marquis in protein content but is of sufficiently good quality to be admitted to all contract grades. It is recommended for Zones 1 and 2.

Red Bobs is a high yielding variety two or three days earlier than Marquis. Although slightly lower than Marquis in protein content, it is of excellent quality. It has a tendency to shatter when fully ripe, and when grown on wooded soils or under very moist conditions it produces piebald or starchy kernels. Red Bobs is recommended for Zones 2, 3, and 4.

Thatcher is a rust resistant variety which matures in about the same time as Red Bobs. It is high in quality and under Alberta conditions yields about the same as Red Bobs. The straw is shorter than that of Marquis. This variety produces rather lustreless kernels, but this does not affect its quality. Thatcher is recommended for all zones.

It may, quite justifiably, be argued that there are some areas for which Garnet alone is suitable. Since the separate grading of Garnet became effective, we are no longer particularly concerned if this variety is grown. It is not recommended as a milling wheat, however, even though there are some districts where no other variety can be successfully grown. It is of course entirely satisfactory as a feed wheat.

Finally, it must not be presumed that the recommendation of Red Bobs and Thatcher for Zone 4 implies that they are considered satisfactory in the same full sense that the recommended varieties are satisfactory for Zones 1 and 2. The fact is that there is **no** entirely satisfactory variety for most of Zone 4. It has already been indicated that it is questionable whether such a variety can ever be produced, and it might be better to face frankly the problem of replacing wheat in this zone by other crops.

GENERAL DISCUSSION

During the past few years there has been a great deal of discussion concerning the quality of Alberta-grown wheat. Much of this discussion has been uninformed and confused both because data were lacking and because the participants each had his own conception of what "quality" meant. It is the sincere hope of the writers that the results presented in this bulletin will supply the needed data, and indicate the real meaning of quality. It has been necessary to emphasize again and again that the quality of northern-grown wheat is not nearly so good as that of wheat grown on the prairies.

It also seems essential to emphasize again and again that we must keep the export market in mind when discussing quality. Domestic millers can, and do, select the wheat which they mill in order to manufacture the type of finished product that best meets the demand. Importers of our wheat cannot readily make such selection, but they buy our wheat because it is "strong" wheat and they expect that they will get at least average quality. The writers are convinced that if every farmer growing wheat in the northern zones could talk with representatives of the buyers of our wheat, nearly every one would adopt forthwith the methods of management most likely to improve the quality of our wheat. One cargo of poor quality wheat damages our reputation far out of proportion to the volume involved, and it would be much better if such cargoes could be eliminated.

It is not the purpose of this bulletin to consider in any detail the ways in which such elimination could be accomplished if improvement of the quality of northern-grown wheat is not effected. It would be possible to prevent low protein cargoes from being sold in the contract grades, and from time to time various suggestions have been made. Some of them are worthy of brief mention. The first involves protein grading; that is, the paying of premiums for high protein wheat, which implies discounts for low protein samples. The second involves the zoning of the wheat producing area of western Canada on a quality basis. The third is that minimum protein levels be set for each contract grade. All of these plans would entail increased labor and expense in the grading of our crop and all, it is worth noting, would work to the disadvantage of the northern farmer. Some such innovation may be justified but, if everything were done that can be done to improve the quality of northern-grown wheat, the need for such action would be considerably less than it is at present.

This bulletin has dealt with wheat and only wheat. The reader is reminded that those parts of Alberta which produce the poorest wheat, produce excellent malting barley and flax.

There can be no unlimited expansion of the acreage of these crops at present, but future expansion should take place in the north and not on the prairies. Hard spring wheat is, and should remain, the main prairie-grown cereal, but everything possible should be done to diversify the crops grown in the northern parts of the province. If a systematic effort is made by everyone concerned there is little doubt that a vast improvement, not only in the quality of wheat, but in the general welfare of the farmers and farm communities throughout the north and north-west parts of the province can be effected.

SUMMARY

The results presented in this bulletin give a picture of the quality of Alberta-grown wheat as it has existed during the past five years. An attempt has also been made to outline how the most serious deficiencies may be bettered. The principal conclusions may be summarized as follows:

The quality of wheat grown on the prairies and south-eastern part of the parkland belt (Zones 1, 2, and 3a) is generally good. This wheat, except under abnormal conditions, will meet every demand made on hard spring wheat, both by domestic and foreign users. Wheat from Zones 1 and 2 is somewhat better than that from Zone 3a, but there is little, if any, danger of a buyer being dissatisfied with wheat from any of these zones.

The quality of wheat grown in the "northern" zones (3b and 4) is decidedly poorer. Much of this wheat, in an average year, is below the standard expected of hard spring wheat and, if shipped without mixing with better quality wheat, will certainly cause dissatisfaction to the overseas buyer. It is unfortunate but true that, under normal conditions, wheat grown in these zones is more likely to be segregated and shipped without mixing than is the wheat from almost any other part of western Canada. At present, due to wartime conditions, most of the Alberta-grown wheat moves east and thus is much more likely to be mixed with better quality wheat than under normal marketing conditions.

Extensive experimental work proves that a decided improvement of northern-grown wheat can be effected if the best methods of soil management are adopted. It is recommended that wheat be grown only on land which has previously grown legumes or a legume-grass mixture and that both the legume crop and the wheat be fertilized. Either ammonium sulphate or 16-20 ammonium phosphate should be used at a rate of 50 to 60 pounds per acre on the grain and perhaps somewhat less on the legumes. These recommendations may not be satisfactory for Zone 4b.

Only recommended wheat varieties should be grown. The varieties recommended for Alberta are as follows:

Zone 1—Canus, Marquis, Thatcher;
Zone 2—Canus, Marquis, Red Bobs, Thatcher;
Zone 3—Red Bobs, Thatcher, Marquis in favored sections;
Zone 4—Red Bobs, Thatcher, Marquis in especially favored parts of 4b.

These varieties are listed in alphabetical order, not in order of preference.

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